A COMPARISON OF HIGH AND LOW VELOCITY PITCHERS IN FASTPITCH SOFTBALL

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A two-dimensional biomechanical comparison of 10 "high velocity" and 10 "low velocity" softball pitchers was done to assess kinematic similarities and differences. While angular velocities of the shoulder, wrist, and elbow are often believed to be important in determining ball velocity, they were not different between high and low velocity groups for these data. Significant differences ($p<0.05$) were found between the groups for center of mass (COM) horizontal velocity and displacement. Additionally, the angular velocity of trunk extension was significantly different ($p<0.05$) between the two groups. Perhaps coaches and trainers should place more emphasis on the use of somatic motions in the pitch than on the arm motions of moderate to high velocity pitchers.

KEY WORDS: fastpitch softball, pitching, technique

INTRODUCTION: Fastpitch softball is a sport that has grown immensely over the last two decades. With a surge in popularity after being a major women's sport in the last two Olympic games, softball has become a focal point for researchers and trainers all over the world. Being the key player on the field, the softball pitcher has become a point of particular interest. Without an effective pitcher, a team cannot be successful. For this reason, improving softball pitching technique, increasing ball velocity, and reducing the risk of injury has become a primary concern of coaches.

The most common pitch used is the windmill pitch, which involves circumduction of the shoulder through a primarily sagittal plane of motion. The segmental coordination of the pitch is critical to its success. According to Putnam (1993), throwing motions such as the fastball pitch follow a proximal-distal sequence that brings about the summation of speed principle. Alexander & Haddow (1982) support the theory of the pitch being a sequential motion and further suggest that the deceleration of the proximal segments helps add momentum to the ball.

Past research has indicated an association between somatic motion and ball velocity (Leahy 1983; Olson & Hunter, 1987; Werner 1994, 1995a; Werner, Murray, Levy, Smith, Plancher, & Hawkins, 1996). Forward motion of the center of mass (COM), step length, hip rotation, and knee angle are among the other variables believed to be important for ball speed and pitching skill (Leahy, 1983; Werner, et al., 1996; Olson & Hunter, 1987). According to Leahy (1983), maximizing the step length causes an increase in hip and shoulder motion and increases the velocity of the pitch. Werner (1995, p. 23) suggested, "weight shift was the 'cornerstone' for coordination in pitching". Werner, Murray, Levy, Smith, Plancher, & Hawkins (1996) added that the way in which the pitcher steps can increase or decrease ball velocity and reduce the amount of stress on the pitcher's shoulder. While kinematic research of the softball pitch has increased in the past few years, few comparisons have been made between pitchers with high and low velocity pitches. Therefore, the purpose of this study was to compare how selected kinematic variables differed between pitchers with high and low fastball velocities.

METHODS: Twenty high school and college level right-handed female softball pitchers who were currently injury free and in training volunteered to participate (age, 17.1±2.7 years; height, 169±6.5 cm; weight, 65.8±2.0 kg; years experience, 5.4±4.5 years). The subjects were from Kansas, Missouri, Illinois, and Iowa. Written parental consent was obtained for those under the age of 18. All of the college pitchers played at the NCAA Division II level or higher.

The pitchers were videotaped on a pitching mound located in a bullpen, on the field, or on artificial turf. A Panasonic camcorder (60 Hz) was set approximately 20 meters from the pitching rubber with the optical axis perpendicular to the sagittal plane of motion. The shutter speed was set at 1/1000 of a second.

Following warm up and stretching, each participant was asked to throw ten fastball strikes while being videotaped. The designated catcher was responsible for calling strikes. All pitches were performed with maximum effort.

Data were reduced using a Peak Performance Motion Analysis System. Four of the ten trials were randomly chosen for data reduction. Only the fastest of the 4 pitches was used for final analysis. The data were smoothed using a butterworth filter with an eight-hertz cut-off frequency. Variables chosen for statistical analysis were based on the components of the pitch that seemed most important from a sagittal view. They included peak resultant velocity of the ball (occurring just after release), peak angular velocity of the shoulder, wrist, and elbow joints, peak angular velocity of the trunk (angle taken between the trunk and the horizontal plane), peak horizontal velocity of the COM, vertical and horizontal displacements of COM, and time between shoulder and wrist peak velocities. The timing variable was used to reflect segmental coordination. The elbow was not used for timing because it typically peaked at the same time as the wrist velocity, which was near release. The elbow timing was similar to the results found by Alexander & Haddow (1982).

The 20 pitchers were separated into "high velocity" or "low velocity" groups based on resultant ball velocity median value. A MANOVA was used to determine how the groups differed in the specified variables. An alpha level of 0.05 was used for significance.

RESULTS: The MANOVA results had a significant main effect for group ($p < 0.05$). In the univariate F-tests the resultant ball velocity, COM horizontal velocity, COM horizontal displacement, and trunk extension velocity were significantly different between groups. The vertical displacement of the COM, timing between shoulder and wrist peaks, and the angular velocities were not significantly different. See Table 1 and Figure 1.

Table 1 Variable Means and Standard Deviations by Group (* indicates a significant difference, p<0.05, in the means)

Variable	High Velocity Group	Low Velocity Group
Resultant Ball Velocity (m/s) *	28.0 ± 1.2	24.6 ± 2.4
COM Horizontal Velocity (m/s) *	2.9 ± 0.5	2.4 ± 0.6
COM Horizontal Displacement (m) *	3.1 ± 0.5	2.6 ± 0.3
COM Vertical Displacement (m)	1.9 ± 0.2	1.8 ± 0.3
Trunk Extension Velocity (deg/s) *	262.9 ± 47.7	196.9 ± 50.5
Shoulder Flexion Velocity (deg/s)	1459 ± 142	1491 ± 255
Elbow Flexion Velocity (deg/s)	1230 ± 362	1290 ± 432
Wrist Flexion Velocity (deg/s)	1220 ± 505	1303 ± 709
Time Between Shoulder and Wrist Peaks (s)	0.15 ± 0.044	0.16 ± 0.034

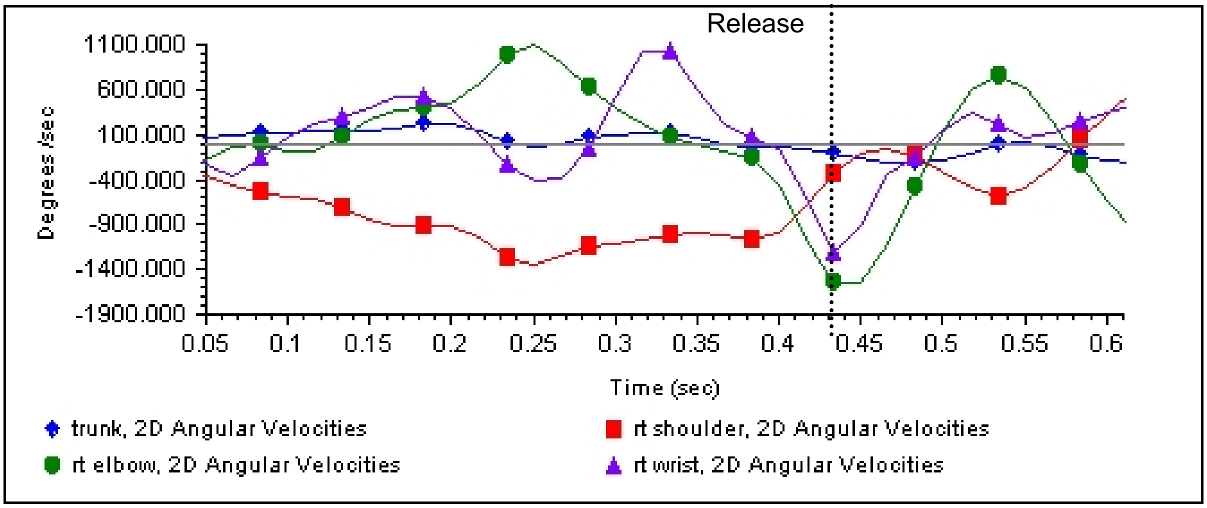

Figure 1 - Sample angular velocity versus time graph for a high velocity subject (every 3rd data point indicated). In this figure negative values represent flexion and positive values represent extension.

DISCUSSION: Differences were clearly evident between the high and low velocity groups. While only selected variables were analyzed, the differences suggest how the higher velocity subjects were able to attain greater ball velocity than the lower velocity subjects.

Ball velocity does seem to depend partly on forward COM velocity, as proposed by Olson & Hunter (1987). The horizontal velocity of COM difference contributed to ball velocity because of the additive nature of velocity. Increases in the pitchers somatic horizontal velocity were likely added to the ball horizontal velocity at release (Putnam, 1993). The COM horizontal velocity difference may be an indication of the higher velocity pitchers development of lower limb drive (Alderson & Elliott, 2000), and may not have as great an influence on arm angular velocities for pitchers of higher skill level.

The second somatic variable of interest was the horizontal displacement of COM. Several researchers have suggested transfer of mass to be a valuable element in pitching (Olson & Hunter, 1987; Werner, 1994, 1995b; Werner, et al. 1996). The transfer of mass, as represented here by horizontal displacement of the COM, is important for the transfer of energy from the lower extremity to the upper extremity (Werner, 1995b). The COM motion may also reflect better use of the non-throwing arm (Werner, 1994). Moreover, Werner et al. (1996) states that the pitchers who had a longer step length tended to have less stress on the shoulder, which may suggest an injury avoidance advantage for the longer horizontal displacement of the COM.

Vertical COM displacement was not found to be significant. It is possible that some pitchers have an increased vertical displacement in order to intimidate the batter, or because they believe it makes them throw harder. Many believe the benefit comes from increased potential energy that is transferred to ball velocity during the downward phase of the throw. This study suggests there is no ball velocity benefit to vertical displacement and it could be a waste of energy for the pitcher.

One of the most interesting differences between the groups was trunk extension velocity. By starting the pitch with the trunk flexed and then extending, the pitcher was able to start her motion up and forward through extension, aiding somatic movement and adding to overall ball velocity. Perhaps the trunk extension velocity helps the shoulder in its circumduction motion. Because the peak occured during the upward motion of the shoulder it seemed to be an early movement characteristic pitchers used to benefit ball velocity. The trunk extension velocity may be an important part of effective transfer of momentum from the somatic motion of the body to the arm motions.

Unfortunately, the angular velocities of the shoulder, elbow, and wrist were not significantly different between these groups. The elbow did not seem to have much angular displacement and many peak velocities were influenced by 2D limitations. Specifically, long-axis rotation of the shoulder seemed to arbitrarily increase values in some pitchers and this increased the variance of this variable. It is also possible that wrist velocity varied due to the type of pitch. Some pitchers use less wrist flexion in a fastball than for other types of pitches. Other pitchers may use it more with their fastball, perhaps as a result of pitching experience. For our subjects, many combinations of upper extremity angular velocities seem to result in moderate-to-high ball velocities. These variations may be a function of the instruction of the coach, the physiological characteristics of the pitcher, the injury history of the pitcher, and the practice of the pitcher. There was also no difference in segmental timing of the shoulder and wrist between the two groups. Based on the findings of Alexander & Haddow (1982), the loss of arm and trunk velocity prior to ball release was expected. While arm flexion velocities and intersegmental timing is likely to be crucial in younger, less experienced pitchers, the lack of differences for angular velocities and timing variables suggests it has been established for pitchers of this skill level. See Figure 1.

Conclusion: For these pitchers, somatic variables differed more than segmental variables. Moderate-to-advanced players may benefit more from instruction related to somatic motion than to instruction related to arm speed. The pitcher should rely on the larger muscles of the legs and back to increase ball velocity, rather than the smaller ones of the arm. This may decrease the stress on the arm and thus decrease the chances of overuse injuries as well as increase the time to onset of fatigue.

REFERENCES:

Alderson, J. & Elliott, B. (2000). Kinetics of the windmill softball pitch for women. In Sanders & Gibson (Eds.), *Biomechanics in Sports XVII* (pp. 277-280). Perth: Edith Cowan University.

Alexander, M., & Haddow, J. (1982). A kinematic analysis of an upper extremity ballistic skill: The windmill pitch. *The Canadian Journal of Applied Sports Science,* 7 (3), 209-217.

Leahy, C. (1983). Simple approach to windmill pitching. *Coaching Review,* 43-44.

Olson, J., & Hunter, G. (1987). Biomechanical and anatomic analysis and conditioning techniques for the windmill style fast pitch in softball. *Journal of Applied Research in Coaching and Athletics,* 2, 115-125.

Putman, C. (1993). Sequential motions of body segments in striking and throwing skills: Descriptions and explanations. *Journal of Biomechanics,* 26, 125-135.

Werner, S. (1994). Biomechanics of pitching. *Fastpitch World,* 7, 23, 28

Werner, S. (1995a). More analyses of arm speed in windmill pitching. *Fastpitch World,* 7 (Jan), 22.

Werner, S. (1995b). Weight shift in windmill pitching. *Fastpitch World,* 7 (Aug), 23.

Werner, S., Murray, T., Levy, M., Smith, S., Plancher, K., & Hawkins, R. (1996). Report to the coaches: Softball pitching at the 1996 Olympic games. *URL: HTTP://www.shsmf.org/library/articles/olympics1.html.*